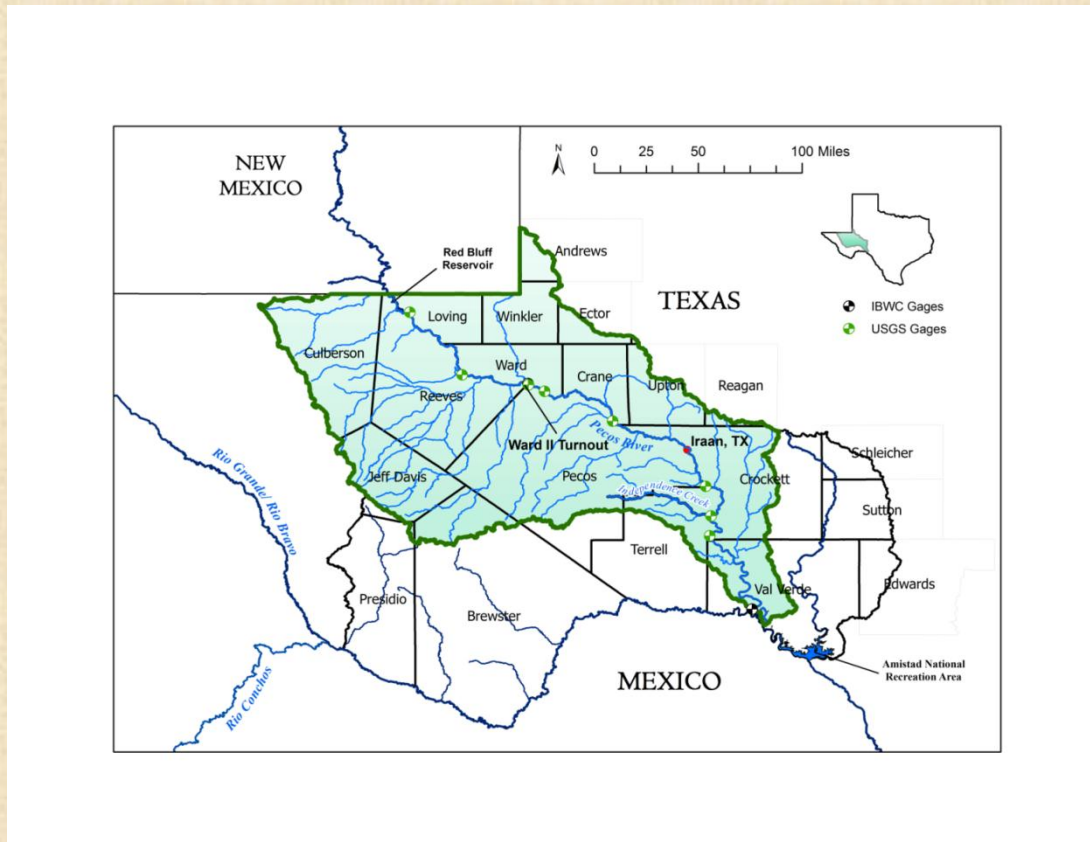
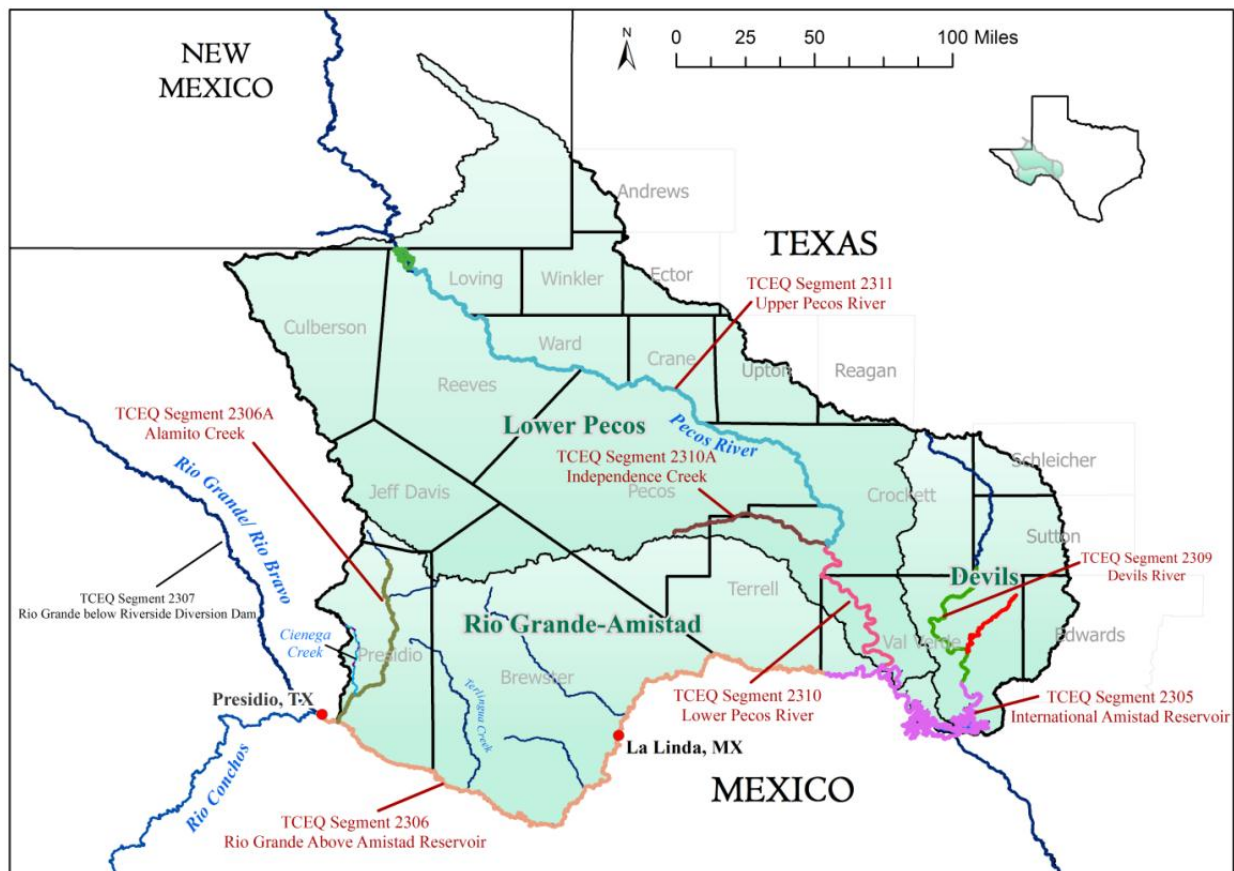


Pecos River Sub-basin

Pecos River Sub-basin

- Sound and unsound reaches
 - Heavily managed
 - Poor water quality
 - Groundwater-fed, rare and unique species in lower
- 6 gages for flow recommendations
- HEFR, water quality reviews, biology overlay





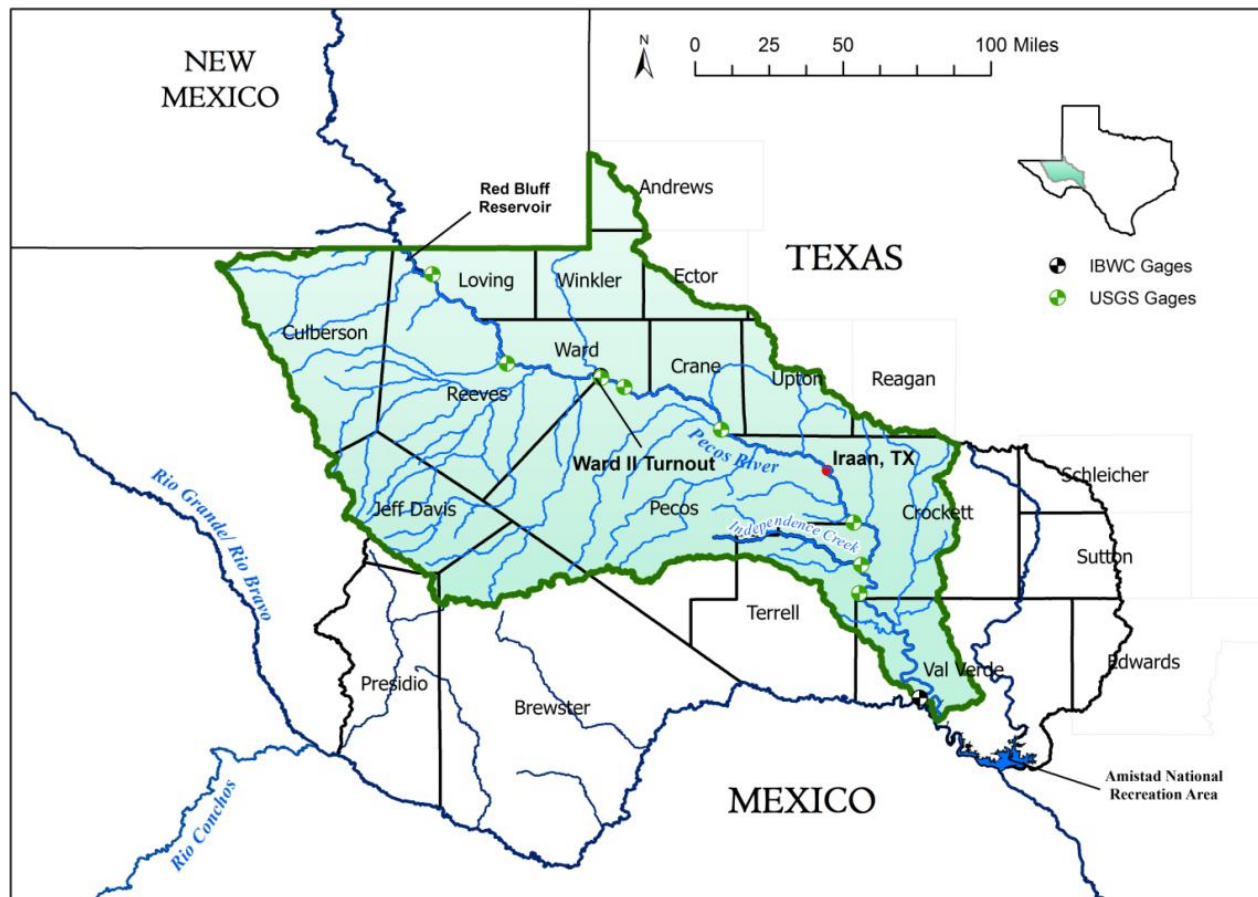
Upper Pecos Segment 2311

Unsound Ecological Environment

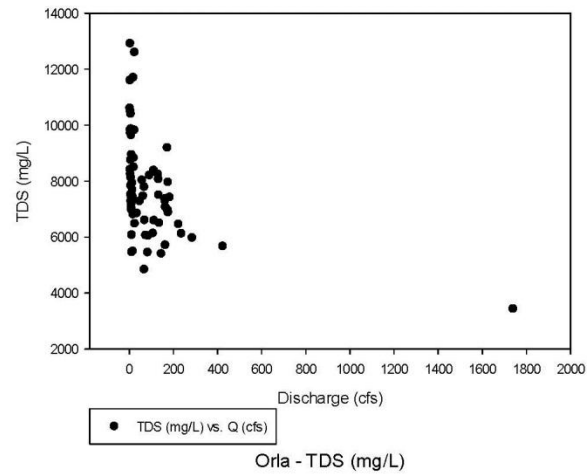
- Water Quality:
 - Dissolved Oxygen Impairment
 - High Total Dissolved Solids
- Fish Communities Have Been Highly Altered
- Not a natural flow regime required to complete the biological life cycles

Upper Pecos Segment 2311

- No flow data from pre-impacted period
- Flow recommendations for 3 gages in this reach are to maintain current conditions only
 - To keep conditions from deteriorating further
 - Not flows needed to maintain original sound ecological environment
- Adaptive Management
 - We recommend studies to determine flow regime needed to maintain a sound ecological environment



Orla - TDS vs. Discharge



Orla - TDS (mg/L)

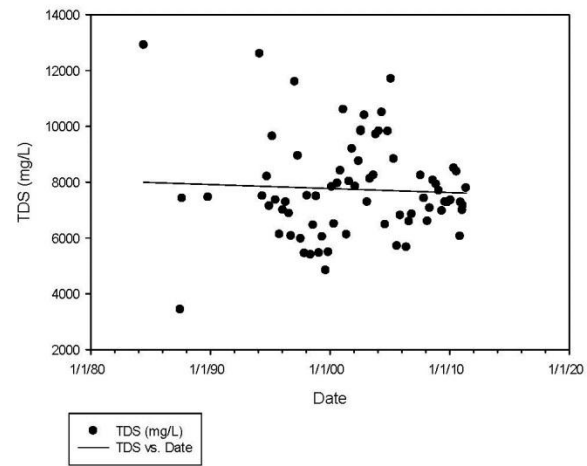


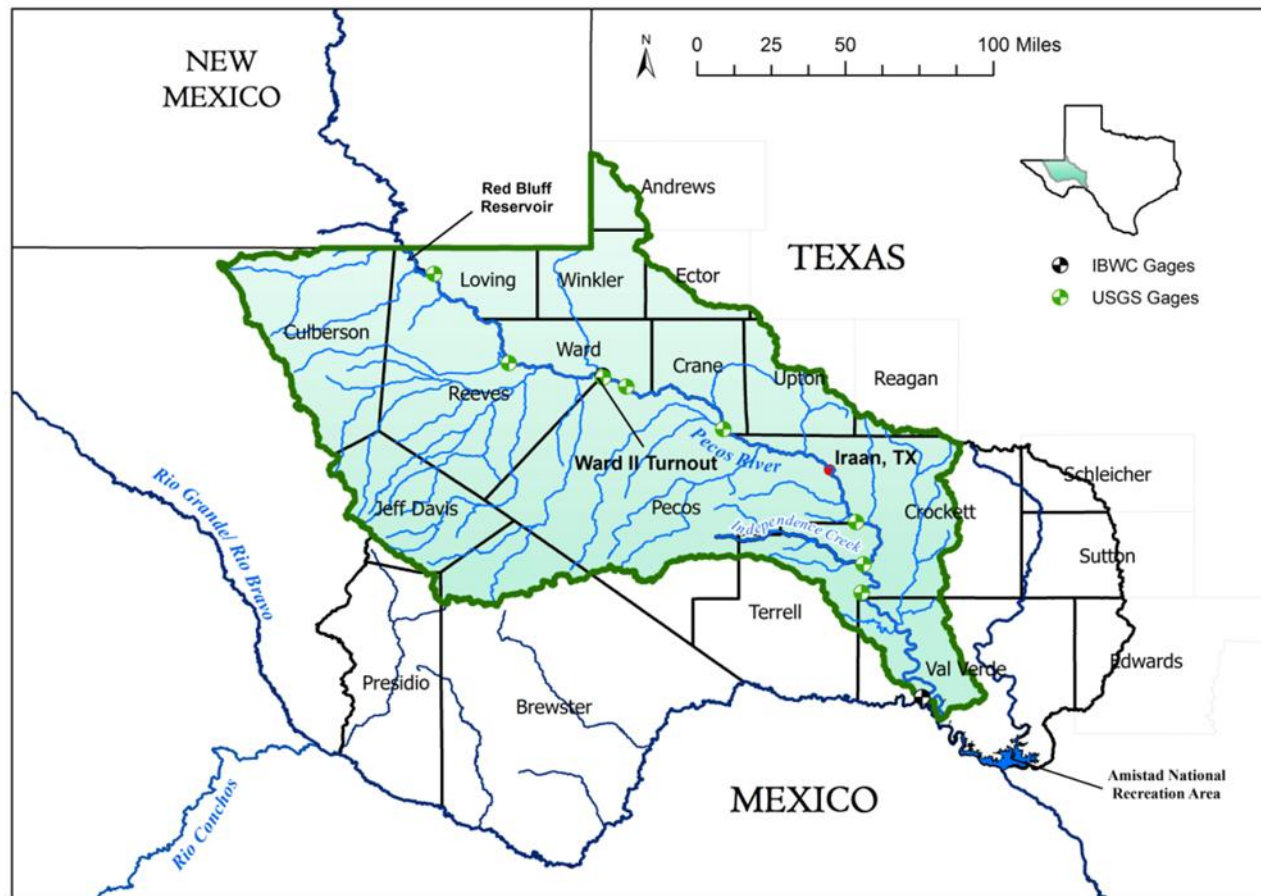
Table Error! No text of specified style in document.-1. Environmental Flow Regime Recommendation, Pecos River near Orla.

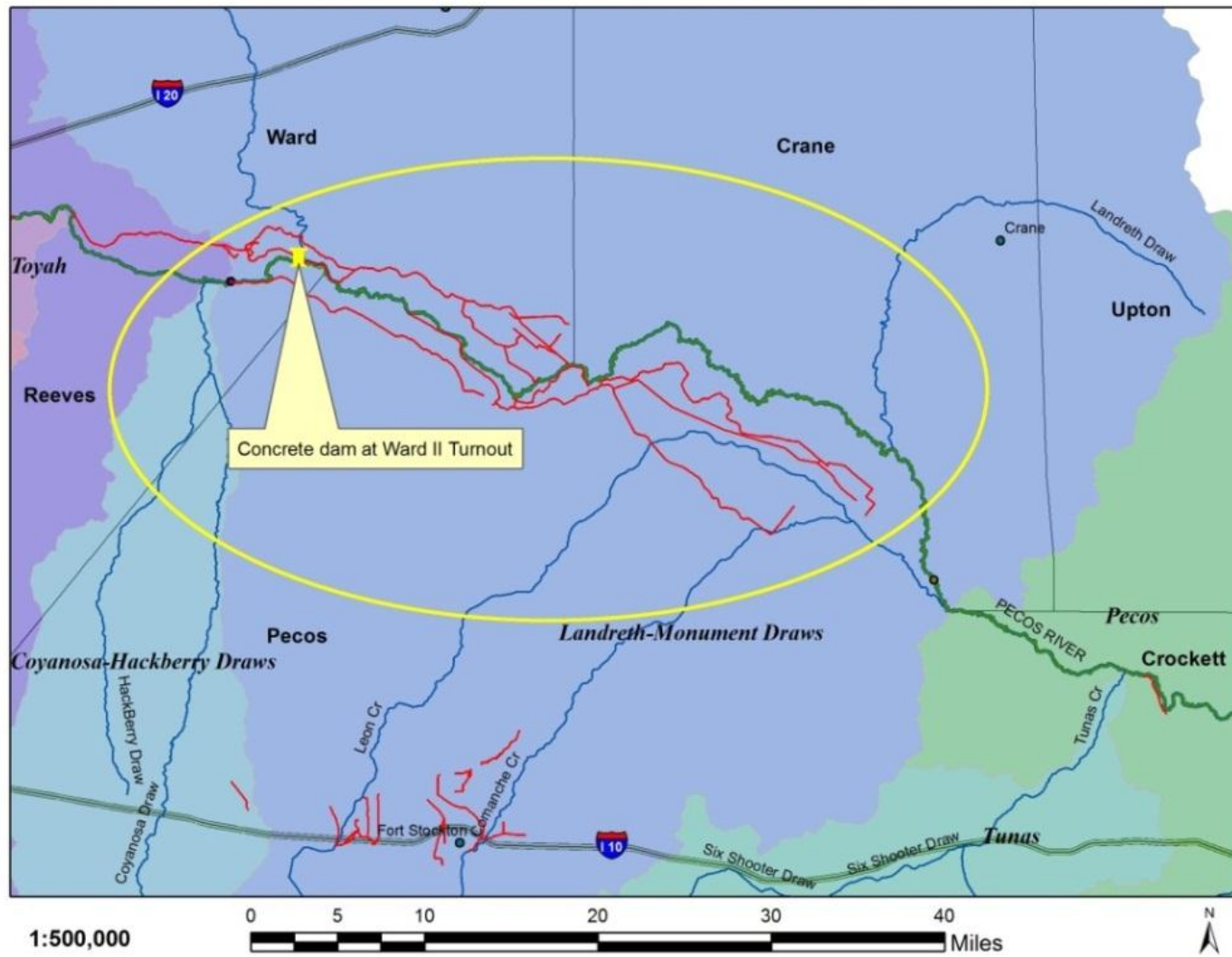
Overbank Flows	Qp: 1,770 ft³/s with Average Frequency 1 per 5 years Volume is 8,979 Duration is 23											
High Flow Pulses	Qp: 1,090 ft³/s with Average Frequency 1 per 2 years Volume is 5,617 Duration is 18											
	Qp: 619 ft³/s with Average Frequency 1 per year Volume is 4,687 Duration is 13											
	Qp: 109 ft³/s with Average Frequency 1 per 2 seasons Volume is 4,460 Duration is 6				Qp: 577 ft³/s with Average Frequency 1 per 2 seasons Volume is 19,077 Duration is 15				Qp: 772 ft³/s with Average Frequency 1 per 2 seasons Volume is #N/A Duration is 12			
	Qp: 53 ft³/s with Average Frequency 1 per 2 seasons Volume is #N/A Duration is 4				Qp: 417 ft³/s with Average Frequency 1 per season Volume is 13,530 Duration is 13				Qp: 429 ft³/s with Average Frequency 1 per season Volume is 1,412 Duration is 9			
	Base Flows (ft³/s)	17 (31.9%)				44 (58.5%)				69 (52.4%)		
12 (50.1%)				15 (72.0%)				33 (68.3%)				
8.8 (67.1%)				9.1 (82.6%)				12 (82.7%)				
Subsistence Flows (ft³/s)	3.3 (92.1%)				3.3 (96.5%)				3.3 (96.6%)			
	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
	Winter				Spring				Monsoon			
	Flow Levels		High (75th %ile)			Notes:						
High (75th %ile)			1. Period of record: 1/1/1938 to 12/31/2009									
Medium (50th %ile)			2. Subsistence and base flows calculated using non-zero flows only.									
Low (25th %ile)			1. Period of record: 1/1/1938 to 12/31/2009									
	Flow Levels		Subsistence			2. Subsistence and base flows calculated using non-zero flows only.						



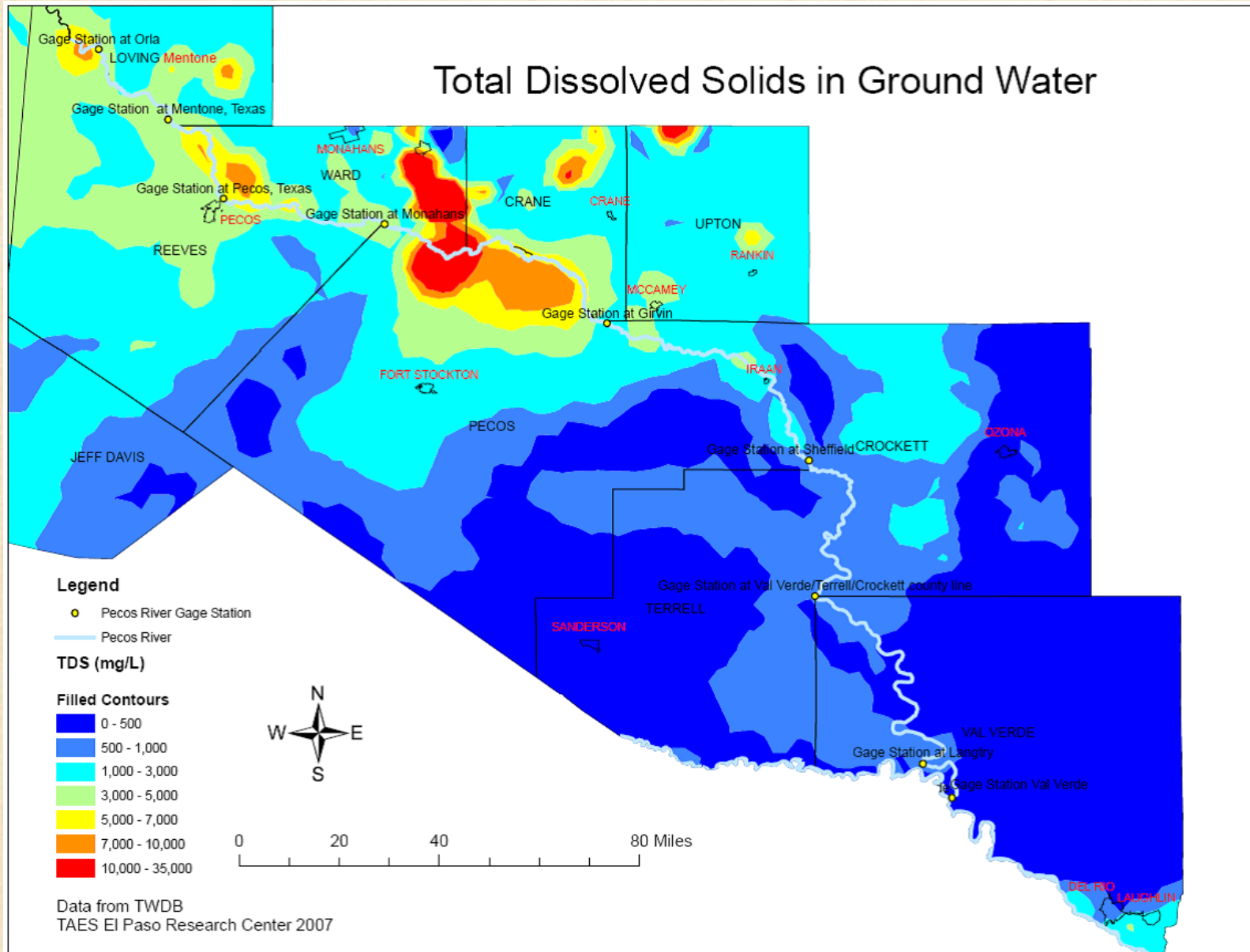
Overbank Flows	Qp: 3,620 ft³/s with Average Frequency 1 per 5 years Volume is 131,386 Duration is 23											
High Flow Pulses	Qp: 2,180 ft³/s with Average Frequency 1 per 2 years Volume is 77,538 Duration is 19											
	Qp: 1,380 ft³/s with Average Frequency 1 per year Volume is 46,974 Duration is 16											
	Qp: 231 ft³/s with Average Frequency 1 per 2 seasons Volume is 8,297 Duration is 12				Qp: 1,190 ft³/s with Average Frequency 1 per 2 seasons Volume is #N/A Duration is 13				Qp: 1,270 ft³/s with Average Frequency 1 per 2 seasons Volume is 40,068 Duration is 14			
	Qp: 231 ft³/s with Average Frequency 1 per season Volume is 1,581 Duration is 6				Qp: 488 ft³/s with Average Frequency 1 per season Volume is #N/A Duration is 9				Qp: 470 ft³/s with Average Frequency 1 per season Volume is 8,422 Duration is 10			
	Qp: 21 ft³/s with Average Frequency 1 per season Volume is #N/A Duration is 3				Qp: 255 ft³/s with Average Frequency 1 per season Volume is 361 Duration is 7				Qp: 224 ft³/s with Average Frequency 1 per season Volume is #N/A Duration is 8			
Base Flows (ft³/s)	32 (45.1%)				78 (50.7%)				104 (45.0%)			
	9.9 (65.5%)				16 (66.6%)				30 (65.5%)			
	5.7 (82.3%)				4.6 (82.1%)				5.2 (82.3%)			
Subsistence Flows (ft³/s)	0.5 (98.8%)				0.4 (98.3%)				0.4 (98.1%)			
	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
	Winter				Spring				Monsoon			
	Flow Levels		High (75th %ile)			Notes:						
Medium (50th %ile)			1. Period of record: 1/1/1902 to 12/31/1935									
Low (25th %ile)			2. Subsistence and base flows calculated using non-zero flows only.									
Subsistence												







Total Dissolved Solids in Ground Water



Girven - TDS vs. Discharge

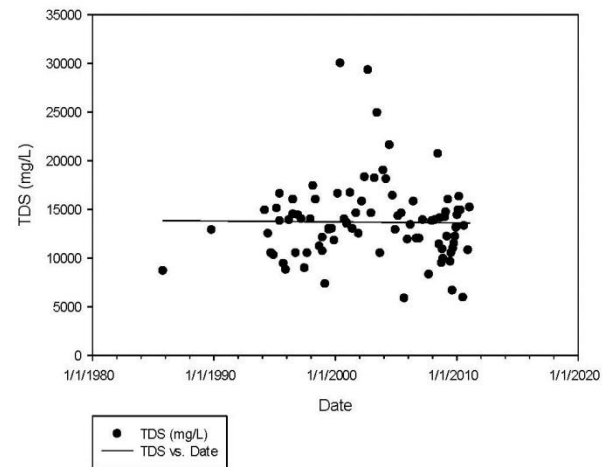
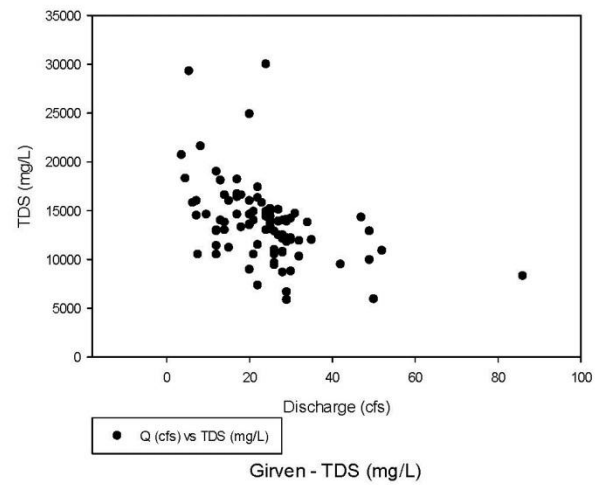


Table Error! No text of specified style in document.-1. Environmental Flow Regime Recommendation, Pecos River near Girvin.

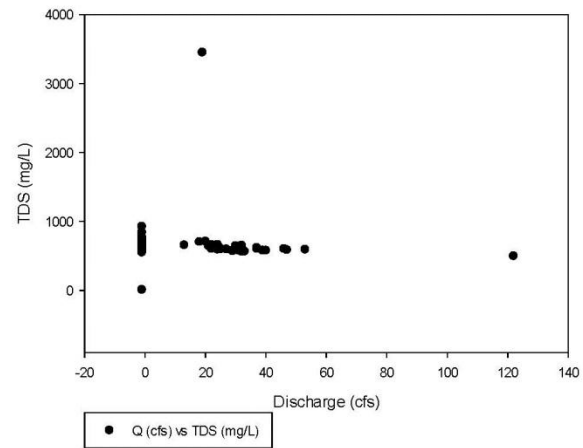
Overbank Flows	Qp: 923 ft ³ /s with Average Frequency 1 per 5 years Volume is 34,421 Duration is 35											
High Flow Pulses	Qp: 299 ft ³ /s with Average Frequency 1 per 2 years Volume is 9,895 Duration is 16											
	Qp: 161 ft ³ /s with Average Frequency 1 per year Volume is 4,511 Duration is 11											
	Qp: 47 ft ³ /s with Average Frequency 1 per 2 seasons Volume is 1,903 Duration is 11			Qp: 152 ft ³ /s with Average Frequency 1 per 2 seasons Volume is 1,756 Duration is 9			Qp: 164 ft ³ /s with Average Frequency 1 per 2 seasons Volume is 2,043 Duration is 10					
	Qp: 231 ft ³ /s with Average Frequency 1 per season Volume is 1,581 Duration is 6			Qp: 72 ft ³ /s with Average Frequency 1 per season Volume is 1,199 Duration is 6			Qp: 100 ft ³ /s with Average Frequency 1 per season Volume is 1,419 Duration is 7					
	Qp: 21 ft ³ /s with Average Frequency 1 per season Volume is #N/A Duration is 3			Qp: 44 ft ³ /s with Average Frequency 1 per season Volume is 1,027 Duration is 4			Qp: 57 ft ³ /s with Average Frequency 1 per season Volume is 1,008 Duration is 4					
Base Flows (ft ³ /s)	32 (53.1%)			25 (45.8%)			27 (42.4%)					
	27 (70.3%)			19 (63.3%)			18 (60.1%)					
	22 (85.4%)			14 (78.7%)			13 (73.9%)					
Subsistence Flows (ft ³ /s)	8.7 (100.0%)			6.8 (95.8%)			6.3 (93.8%)					
	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
	Winter				Spring				Monsoon			
	Flow Levels		High (75th %ile)			Notes:						
			Medium (50th %ile)			1. Period of record: 1/1/1939 to 12/31/2011						
			Low (25th %ile)			2. Subsistence and base flows calculated using non-zero flows only.						
			Subsistence									

Independence Creek Segment 2310A

Sound Ecological Environment

- Water Quality:
 - No impairments
- Fish Communities Intact
- Natural flow regime required to complete the biological life cycles is intact

Independence Creek - TDS vs. Discharge



Independence Creek - TDS (mg/L)

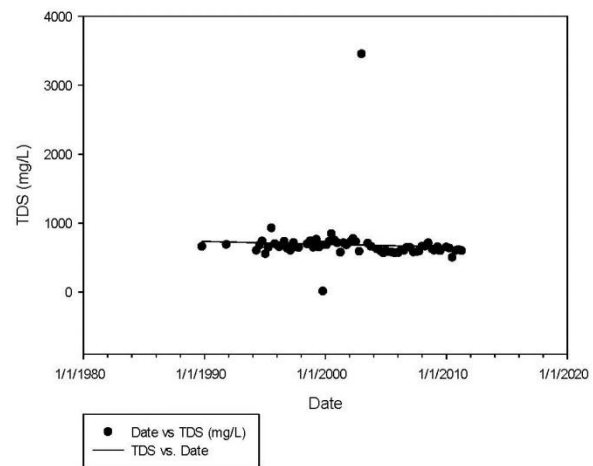


Table Error! No text of specified style in document.-1. Environmental Flow Regime Recommendation, Independence Creek near Sheffield.

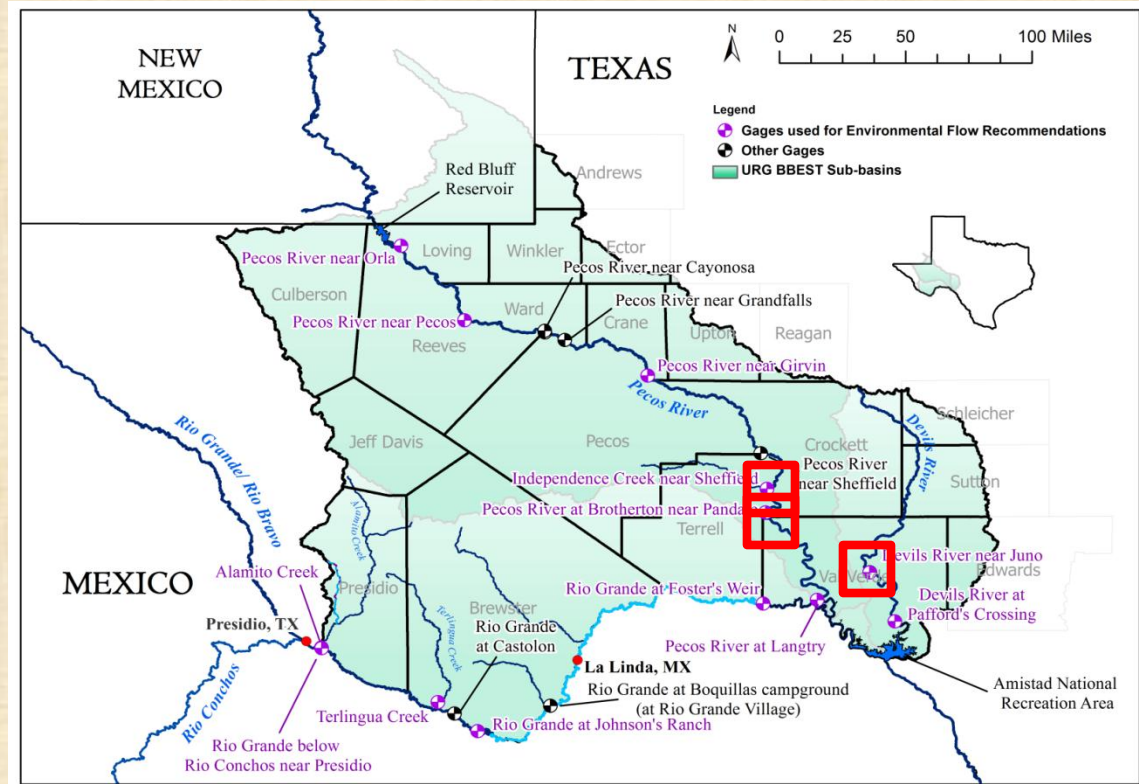
Overbank Flows	Qp: 1,100 ft³/s with Average Frequency 1 per 5 years Volume is 5,800 Duration is 22											
High Flow Pulses	Qp: 612 ft³/s with Average Frequency 1 per 2 years Volume is 3,863 Duration is 18											
	Qp: 182 ft³/s with Average Frequency 1 per year Volume is 2,114 Duration is 11											
	Qp: 33 ft³/s with Average Frequency 1 per 2 seasons Volume is 2,666 Duration is 15				Qp: 100 ft³/s with Average Frequency 1 per 2 seasons Volume is 1,637 Duration is 8				Qp: 231 ft³/s with Average Frequency 1 per 2 seasons Volume is 1,777 Duration is 9			
					Qp: 42 ft³/s with Average Frequency 1 per season Volume is 1,115 Duration is 7				Qp: 44 ft³/s with Average Frequency 1 per season Volume is 1,013 Duration is 5			
Base Flows (ft³/s)	40				40				40			
	25				25				25			
Subsistence Flows (ft³/s)	18 (99.2%)				17 (96.1%)				17 (92.5%)			
	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
	Winter				Spring				Monsoon			
	Flow Levels		High (75th %ile)				Notes:					
Medium (50th %ile)				1. Period of record: 1/1/1975 to 2/28/1985 and 3/1/2000 to 12/31/2009								
Low (25th %ile)				2. Subsistence and base flows calculated using non-zero flows only.								
Subsistence												

Biology Overlay

Component	Hydrology	Geomorphology	Biology	Water Quality
No-Flow Periods	Flow ceases between perennial pools	Encroachment of vegetation	Generally stressful for fish communities	Temperatures rise and oxygen levels decrease. These condition sometimes cause fish kills
Subsistence Flows	Infrequent low flows	Increased deposition of fine and organic particles, encroachment of vegetation	Provide restricted aquatic habitat limit connectivity	Elevate temperature and constituent concentrations Maintain adequate levels of dissolved oxygen
Base Flows	Average flow condition, including variability	Maintain soil moisture and ground water table Maintain a diversity of habitats, Exports or transports sediment?	Provide suitable aquatic habitat, Provide connectivity along channel corridor	Provide suitable in-channel water quality
High Flow Pulses	In channel short duration, high flows	Deposit sediment, development of inset flood plains; Prevent encroachment of riparian vegetation	Serve as recruitment events for organisms; Provide connectivity to near-channel water bodies	Restore in-channel water quality after prolonged low flow periods. Episodic in nature and associated with fish kills (anecdotal, no real investigation of this yet)
Overbank flows	Infrequent high flows that exceed the channel	Provide lateral channel movement and floodplain maintenance; Recharge floodplain water table; form new habitats; flush organic material into channel; Deposit nutrients in floodplain	Provide new life phase cues for organisms; Maintain diversity of riparian vegetation; Provide conditions for seedling development; Provide connectivity to floodplain	Restore water quality in floodplain water bodies
Channel Maintenance	For most streams, channel maintenance occurs mostly during pulse and overbank flows	Long-term maintenance of existing channel morphology	Maintains foundation for physical habitat features instream	Water quality condition like those during pulse overbank flows

Biology Overlay – Flow-Habitat

- 3 sites with groundwater fed base flow maintaining habitats
 - Pecos River (sound)
 - Independence Creek
 - Devils River (1)



Fish Habitats



Thomas, Bonner, and Whiteside 2007



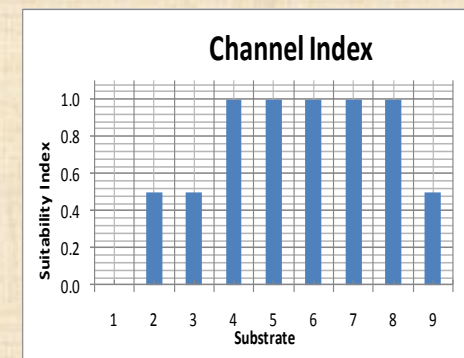
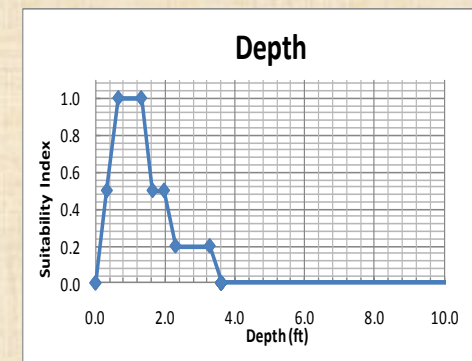
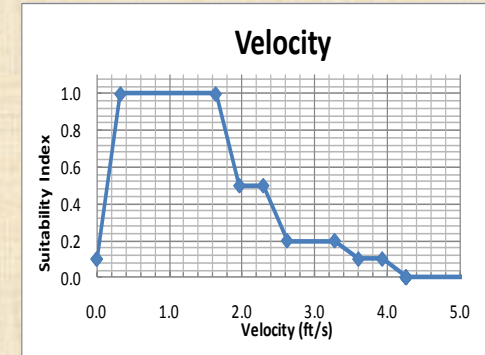
Thomas, Bonner, and Whiteside 2007

Focal Fish Species

Focal Species	Devils	Indy	Pecos	Riffle	Shallow Run	Deep Run	Shallow Pool	Deep Pool
Manantial roundnose minnow	Yes	Yes	Yes	x	X	x		
Devils river minnow	Yes					X		
Proserpine shiner	Yes	Yes	Yes	x	X	x		
Texas shiner	Yes	Yes	Yes		x	X	x	
Tamaulipas shiner			Yes		X	x		
Sand shiner	Yes	Yes			X	X	X	
Headwater catfish		Yes				X	x	x
Gray redhorse	Yes	Yes	Yes			X	x	x
Mexican tetra	Yes	Yes	Yes		X	X		
Largemouth bass	Yes	Yes	Yes			x	x	X
Longear sunfish	Yes	Yes	Yes		x	x	X	x
Rio Grande darter	Yes	Yes	Yes	X	X			
Rio Grande cichlid	Yes	Yes	Yes					X

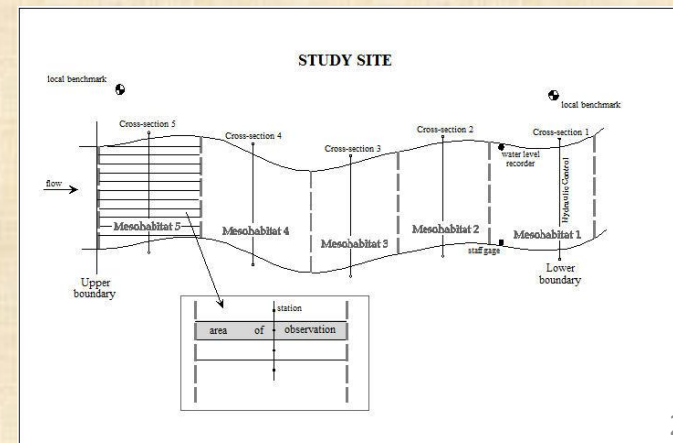
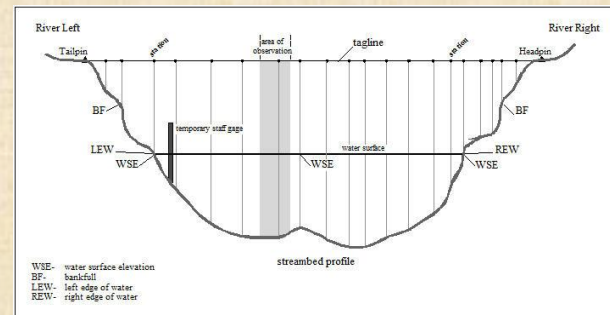
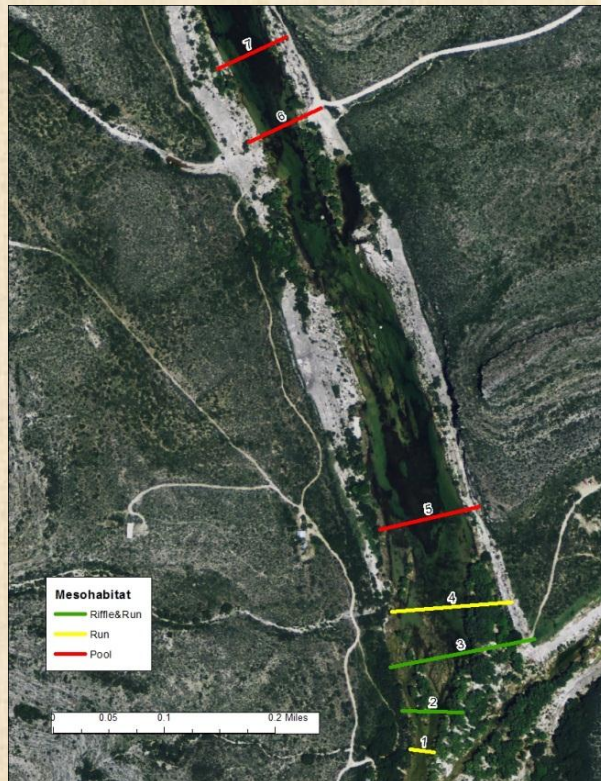
Habitat Suitability Criteria

- How do we know what is suitable instream habitat?
- Quantitative habitat preferences
 - Velocity, depth and substrate type
- Using data from research at our sites



Modeling Approach

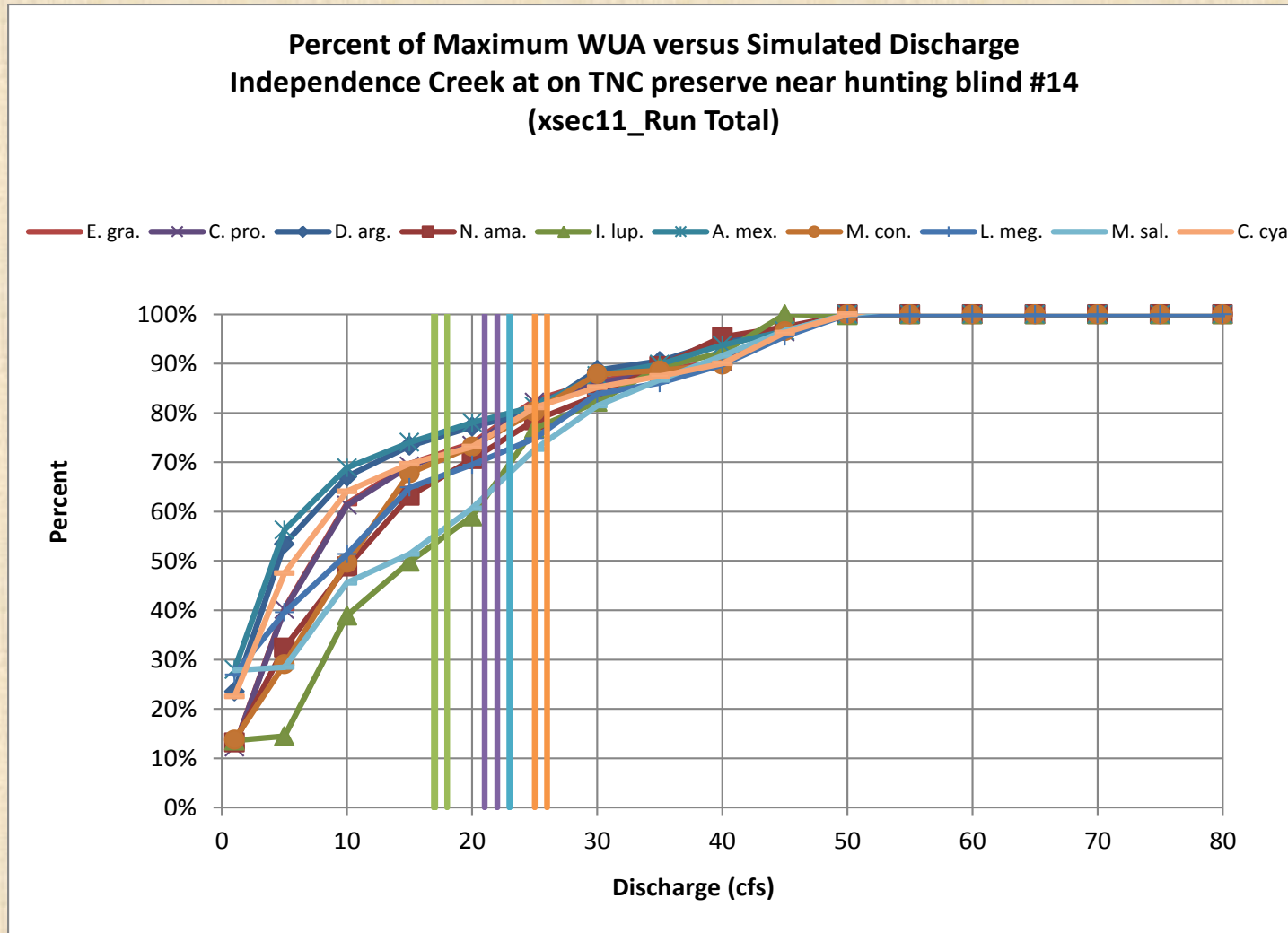
- Assistance from TPWD, TWDB, Sul Ross State Univ with fieldwork
- Contracted for development of models (Trungale Science and Engineering) (Appendix 3.4 in report)



Habitat Analysis

- Base flow recommendations need to maintain enough high quality habitat for species in their “preferred” habitat types
 - 0.5 minimum “quality”, used mesohabitat subsections
- How much is “enough” habitat?
 - Used percent of maximum habitat (% WUA) as the measure
 - Imperiled species – 75% in base-low, 90% in base-medium
 - Other species – 75% in base-medium
- Time series – framework for evaluating potential standards

Independence Creek Results



Indy Creek

- 40 cfs needed to meet criteria for all species
- 2 in riffles
- 2 in runs

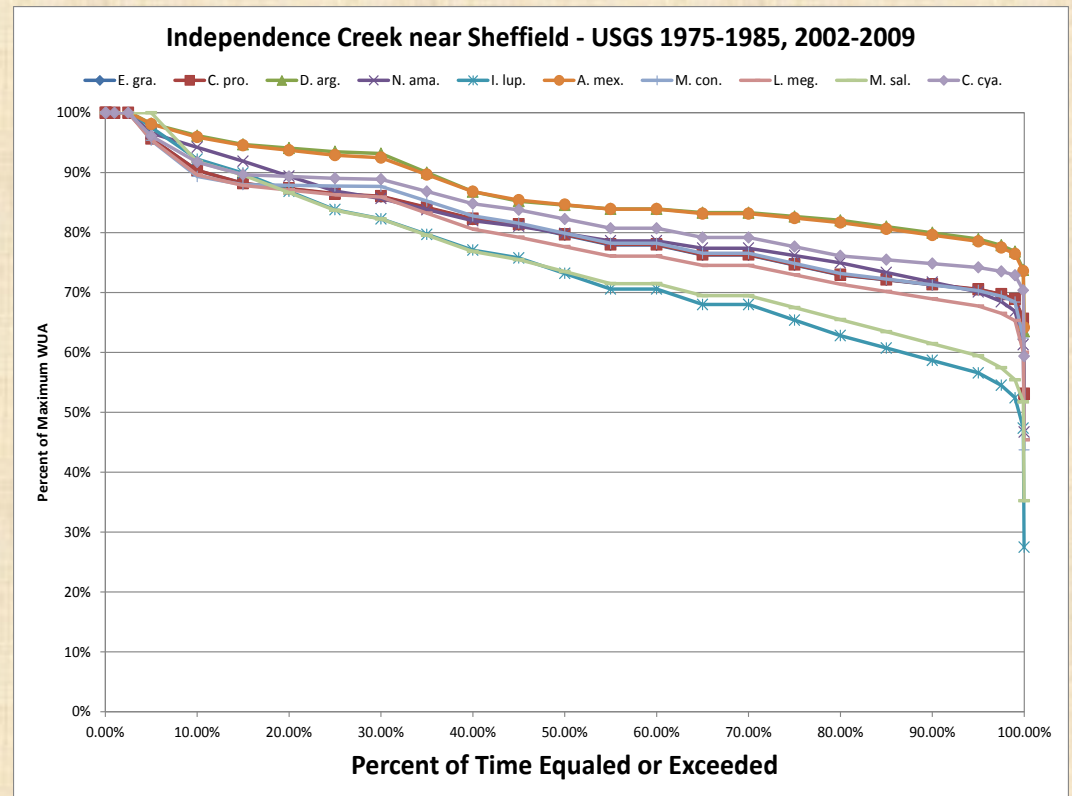
Modeled Flow (FT ³ /S)	C. pro.	D. arg.	N. ama.	M. con.	I. lup.	A. mex.	M. sal.	L. meg.	E. gra.	C. cya.
1	12%	31%	2%	1%	0%	32%	0%	1%	12%	13%
5	51%	58%	48%	43%	16%	60%	13%	35%	51%	49%
10	65%	68%	66%	71%	65%	68%	55%	55%	65%	60%
15	69%	74%	73%	78%	70%	74%	63%	66%	69%	64%
20	71%	79%	79%	80%	85%	78%	79%	74%	71%	68%
25	80%	81%	83%	84%	91%	82%	86%	81%	80%	78%
30	83%	94%	86%	86%	93%	93%	91%	86%	83%	82%
35	85%	96%	95%	87%	96%	96%	95%	88%	85%	84%
40	91%	98%	98%	87%	97%	97%	97%	90%	91%	91%
45	97%	99%	99%	98%	99%	99%	99%	99%	97%	98%
50	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
55	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
60	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
65	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
70	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
75	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
80	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
85	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
90	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
95	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
100	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
125	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
150	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
175	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
200	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
250	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
300	100%	100%	100%	100%	100%	89%	100%	100%	100%	100%
350	100%	100%	100%	100%	100%	87%	100%	100%	100%	100%
400	100%	100%	100%	100%	100%	83%	100%	100%	100%	100%
500	100%	92%	100%	100%	100%	81%	100%	96%	100%	100%

- HEFR + biology overlay
- Reduced to 2 tiers
- 25 cfs, 40 cfs

Overbank Flows	Qp: 1,100 ft³/s with Average Frequency 1 per 5 years Volume is 5,800 Duration is 22												
High Flow Pulses	Qp: 612 ft³/s with Average Frequency 1 per 2 years Volume is 3,863 Duration is 18												
	Qp: 182 ft³/s with Average Frequency 1 per year Volume is 2,114 Duration is 11												
	Qp: 33 ft³/s with Average Frequency 1 per 2 seasons Volume is 2,666 Duration is 15				Qp: 100 ft³/s with Average Frequency 1 per 2 seasons Volume is 1,637 Duration is 8				Qp: 231 ft³/s with Average Frequency 1 per 2 seasons Volume is 1,777 Duration is 9				
					Qp: 42 ft³/s with Average Frequency 1 per season Volume is 1,115 Duration is 7				Qp: 44 ft³/s with Average Frequency 1 per season Volume is 1,013 Duration is 5				
Base Flows (ft³/s)	40				40				40				
	25				25				25				
Subsistence Flows (ft³/s)	18 (99.2%)				17 (96.1%)				17 (92.5%)				
	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	
	Winter				Spring				Monsoon				
	Flow Levels		High (75th %ile)				Notes:						
Medium (50th %ile)				1. Period of record: 1/1/1975 to 2/28/1985 and 3/1/2000 to 12/31/2009									
Low (25th %ile)				2. Subsistence and base flows calculated using non-zero flows only.									
	20												

Independence Creek

- Habitat time series analysis
- Can serve as an aid in evaluating standards
- E.g., no more than 10% decrease in frequency of meeting 90% threshold for imperiled species



Lower Pecos Segment 2310

Sound Ecological Environment

- Altered but sound
- Water Quality:
 - Fewer concerns and impairments
 - TDS reduced by inflow of Independence Creek
- Fish communities more intact, but loss of some big river species
- Natural flow regime required to complete the biological life cycles of “new” communities is intact

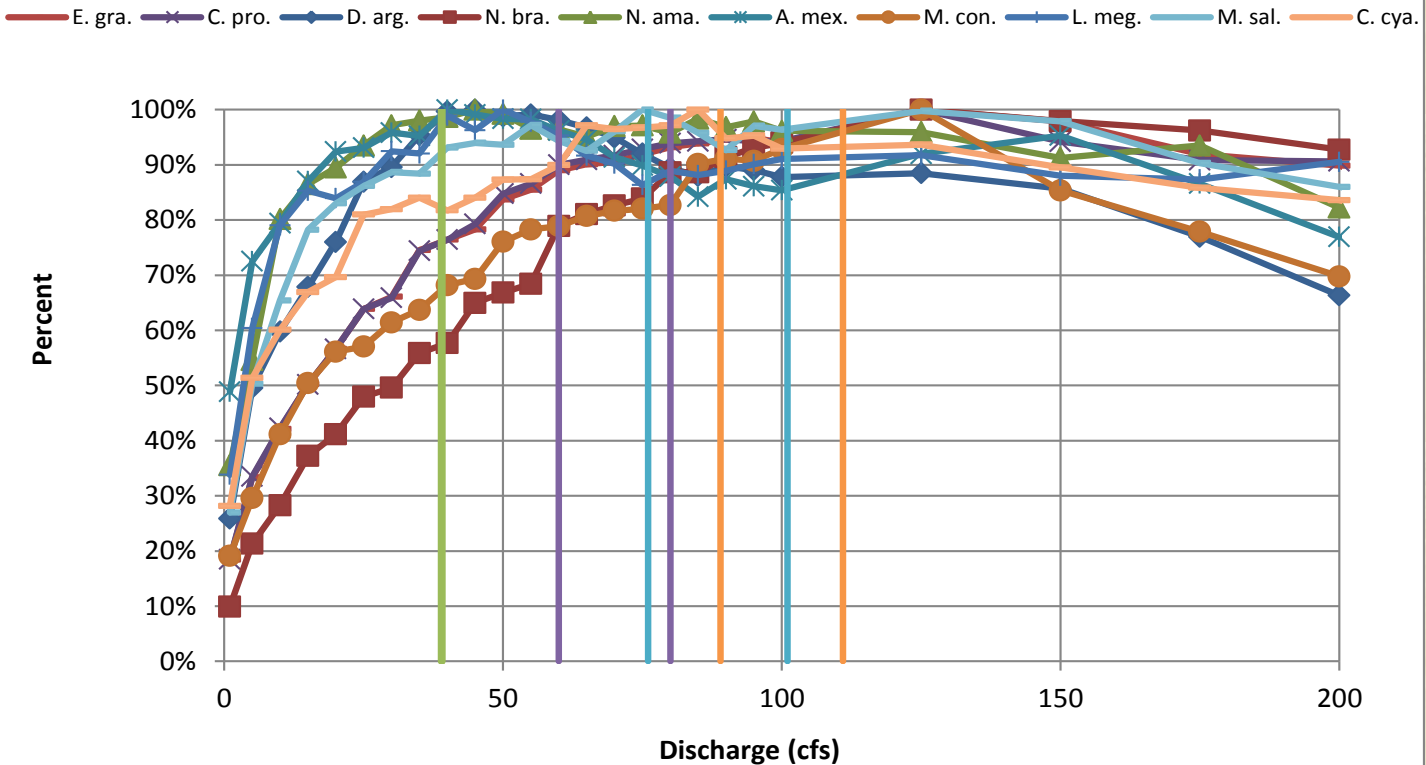
Pecos River at Brotherton Ranch Near Pandale

- In the “sound” reach
- Only 5 years of data
- No HEFR analysis
- Did abbreviated hydrologic analysis to get some idea of initial numbers



Pecos Pandale

Percent of Maximum WUA versus Simulated Discharge
Pecos at approximately 5 to 6 miles upstream of the Pandale crossing
(xsec10_Riffle Total)



Pecos

Pandale

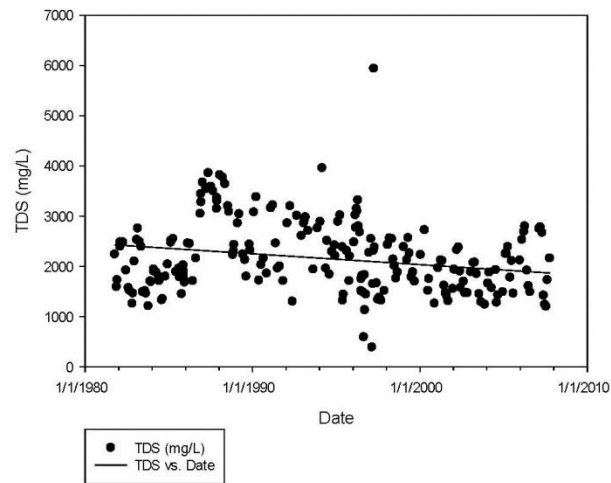
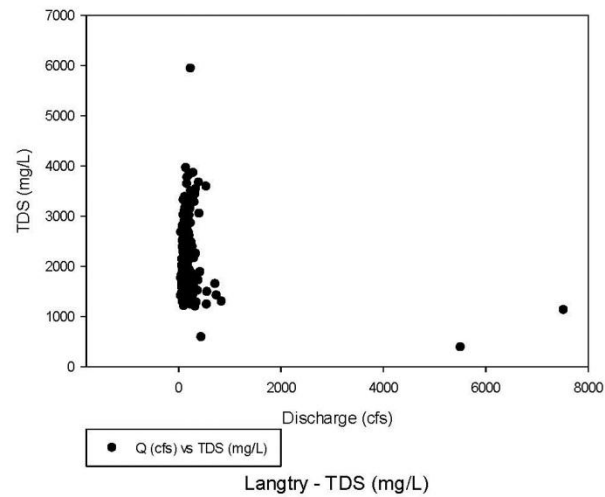
- 90 cfs needed to meet criteria for all species
- 1 in riffles

Modeled Flow (FT ³ /S)	C. pro.	D. arg.	N. ama.	N. bra.	M. con.	A. mex.	L. meg.	M. sal.	E. gra.	C. cya.
1	19%	26%	36%	10%	19%	49%	34%	27%	18%	28%
5	34%	50%	55%	21%	30%	73%	60%	50%	33%	51%
10	42%	60%	80%	28%	41%	79%	79%	65%	42%	60%
15	50%	68%	86%	37%	50%	87%	85%	78%	50%	67%
20	57%	76%	89%	41%	56%	92%	84%	83%	57%	70%
25	64%	87%	94%	48%	57%	93%	87%	86%	64%	81%
30	66%	90%	97%	50%	61%	96%	92%	89%	66%	82%
35	74%	95%	98%	56%	64%	95%	92%	88%	75%	84%
40	76%	100%	99%	58%	68%	100%	99%	93%	76%	82%
45	79%	100%	100%	65%	69%	99%	96%	94%	78%	84%
50	85%	99%	99%	67%	76%	98%	100%	94%	84%	87%
55	87%	99%	97%	68%	78%	98%	98%	97%	85%	87%
60	90%	98%	96%	79%	79%	96%	95%	94%	89%	90%
65	91%	97%	95%	81%	81%	95%	92%	93%	90%	97%
70	92%	95%	97%	83%	82%	91%	90%	96%	91%	96%
75	93%	92%	97%	84%	82%	90%	86%	100%	92%	97%
80	94%	89%	96%	89%	83%	88%	89%	99%	93%	97%
85	94%	88%	98%	89%	90%	84%	88%	96%	94%	100%
90	95%	90%	97%	91%	91%	87%	89%	93%	95%	95%
95	94%	89%	98%	93%	91%	86%	90%	97%	95%	95%
100	94%	88%	96%	94%	93%	85%	91%	96%	94%	93%
125	100%	88%	96%	100%	100%	92%	92%	100%	100%	94%
150	94%	86%	91%	98%	85%	95%	88%	98%	98%	90%
175	91%	77%	94%	96%	78%	87%	87%	90%	92%	86%
200	91%	66%	82%	93%	70%	77%	91%	86%	90%	84%
250	82%	52%	82%	85%	53%	71%	81%	77%	71%	68%
300	69%	44%	93%	81%	48%	71%	65%	77%	56%	54%
350	60%	37%	90%	72%	53%	66%	59%	68%	47%	48%
400	49%	32%	83%	65%	49%	64%	30%	43%	42%	40%
500	34%	27%	64%	51%	34%	57%	21%	28%	30%	29%

Pecos Pandale

Overbank Flows	No flow recommendations											
High Flow Pulses	No flow recommendations											
Base Flows (cfs)	101				90				90			
	80				60				62			
Subsistence Flows (cfs)	39				39				39			
	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
	Winter				Spring				Monsoon			
	Flow Levels		High (75th %ile)				Notes:					
			Medium (50th %ile)				1. Period of record: 1/1/2008 to 12/31/2010					
			Low (25th %ile)				2. Subsistence and base flows calculated using non-zero flows only.					

Langtry - TDS vs. Discharge



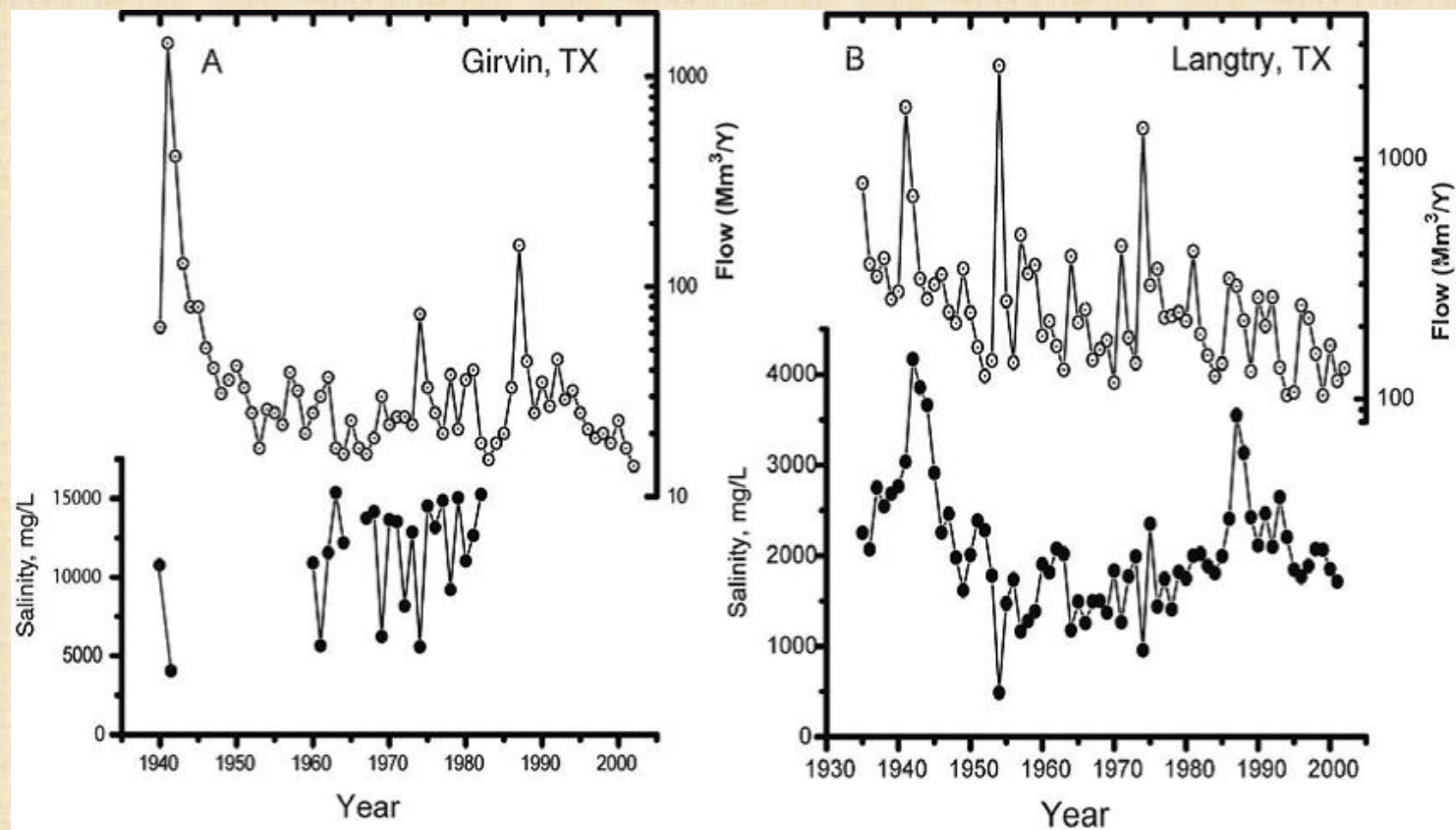


Fig. 9 Historical records of flow and salinity at Girvin and Langtry (original data at Girvin from USGS, these at Langtry from IBWC).

Table Error! No text of specified style in document.-1. Environmental Flow Regime Recommendation, Pecos River at Langtry.

Overbank Flows	Qp: 15,540 ft³/s with Average Frequency 1 per 5 years Volume is 63,337 Duration is 22											
High Flow Pulses	Qp: 7,593 ft³/s with Average Frequency 1 per 2 years Volume 35,590 Duration is 17											
	Qp: 3,991 ft³/s with Average Frequency 1 per year Volume is 23,372 Duration is 14											
					Qp: 2,670 ft³/s with Average Frequency 1 per 2 seasons Volume is 15,836 Duration is 9				Qp: 6,357 ft³/s with Average Frequency 1 per 2 seasons Volume is 33,460 Duration is 17			
					Qp: 569 ft³/s with Average Frequency 1 per season Volume is 6,871 Duration is 6				Qp: 1,441 ft³/s with Average Frequency 1 per season Volume is 14,961 Duration is 9			
					Qp: 252 ft³/s with Average Frequency 1 per season Volume is 5,468 Duration is 4				Qp: 459 ft³/s with Average Frequency 1 per season Volume is 11,300 Duration is 5			
Base Flows (ft³/s)	182 (51.8%)				158 (47.4%)				163 (47.2%)			
	154 (69.1%)				131 (65.3%)				135 (60.9%)			
	133 (85.0%)				109 (80.5%)				108 (73.7%)			
Subsistence Flows (ft³/s)	70 (99.9%)				76 (97.6%)				76 (93.3%)			
	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
	Winter				Spring				Monsoon			
	Flow Levels		High (75th %ile)			Notes:						
			Medium (50th %ile)			1. Period of record: 1/1/1967 to 12/31/2010						
			Low (25th %ile)			2. Subsistence and base flows calculated using non-zero flows only.						
			Subsistence									

Adaptive Management

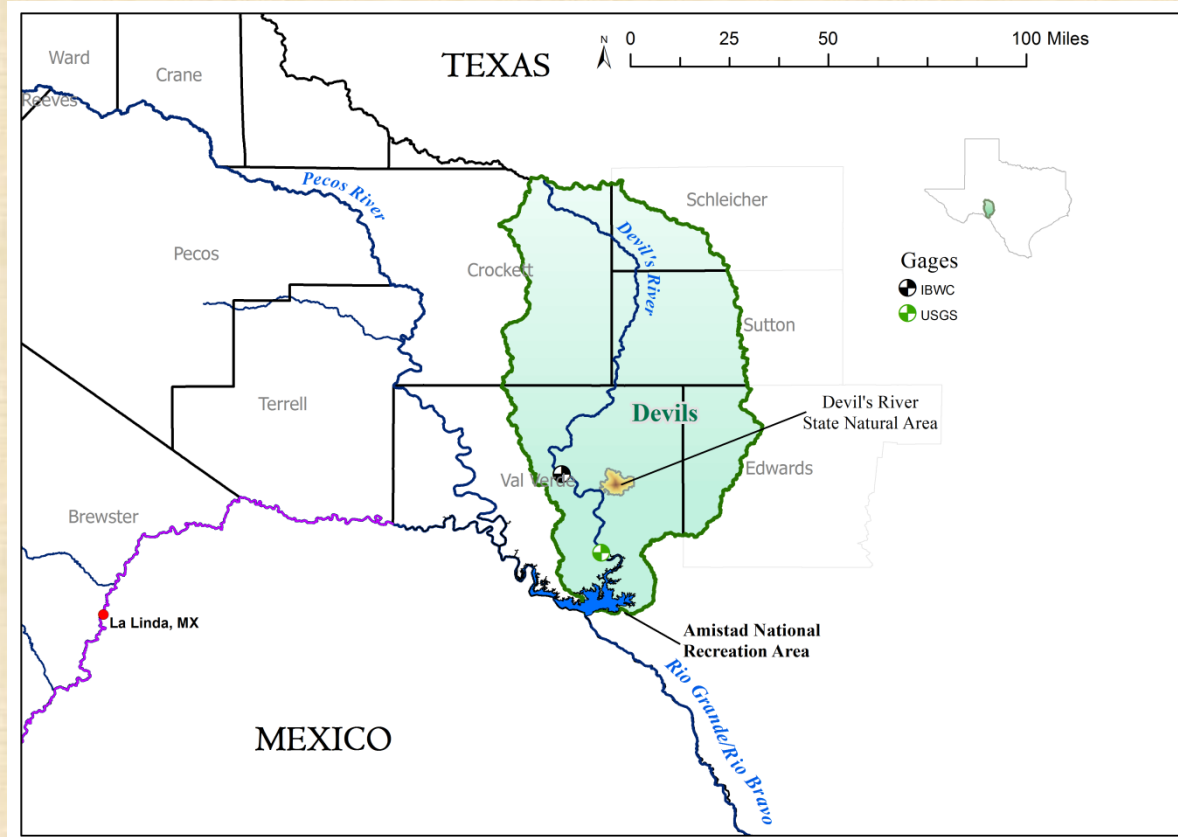
- Gage Maintenance
- Complete Water Balance for the Pecos River
- Sediment Transport and Geomorphic Processes
- Benthic and Mussel Health
- Water Quality vs Flow

Concerns

- Improper Flushing of the Pecos River
- Potential need for a River Authority
- Groundwater Extraction for Exporting for Municipal Authorities
- Growing momentum to declare the Pecos River as an inland saline water body.

Devils River Sub-basin

Devils River Sub-basin



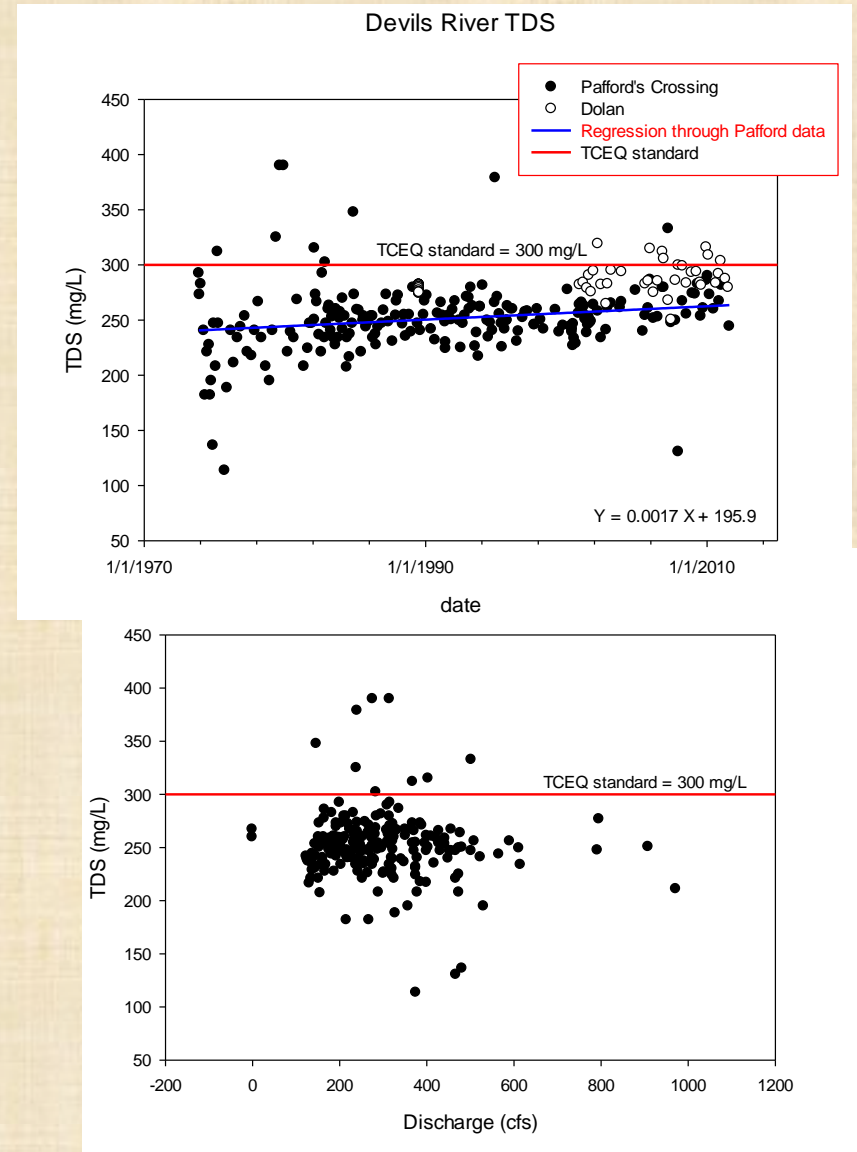
Devils River

- Sound
 - High water quality
 - Rare and unique species
 - Groundwater
- 2 gages for flow recommendations
- HEFR, water quality review, biology overlay



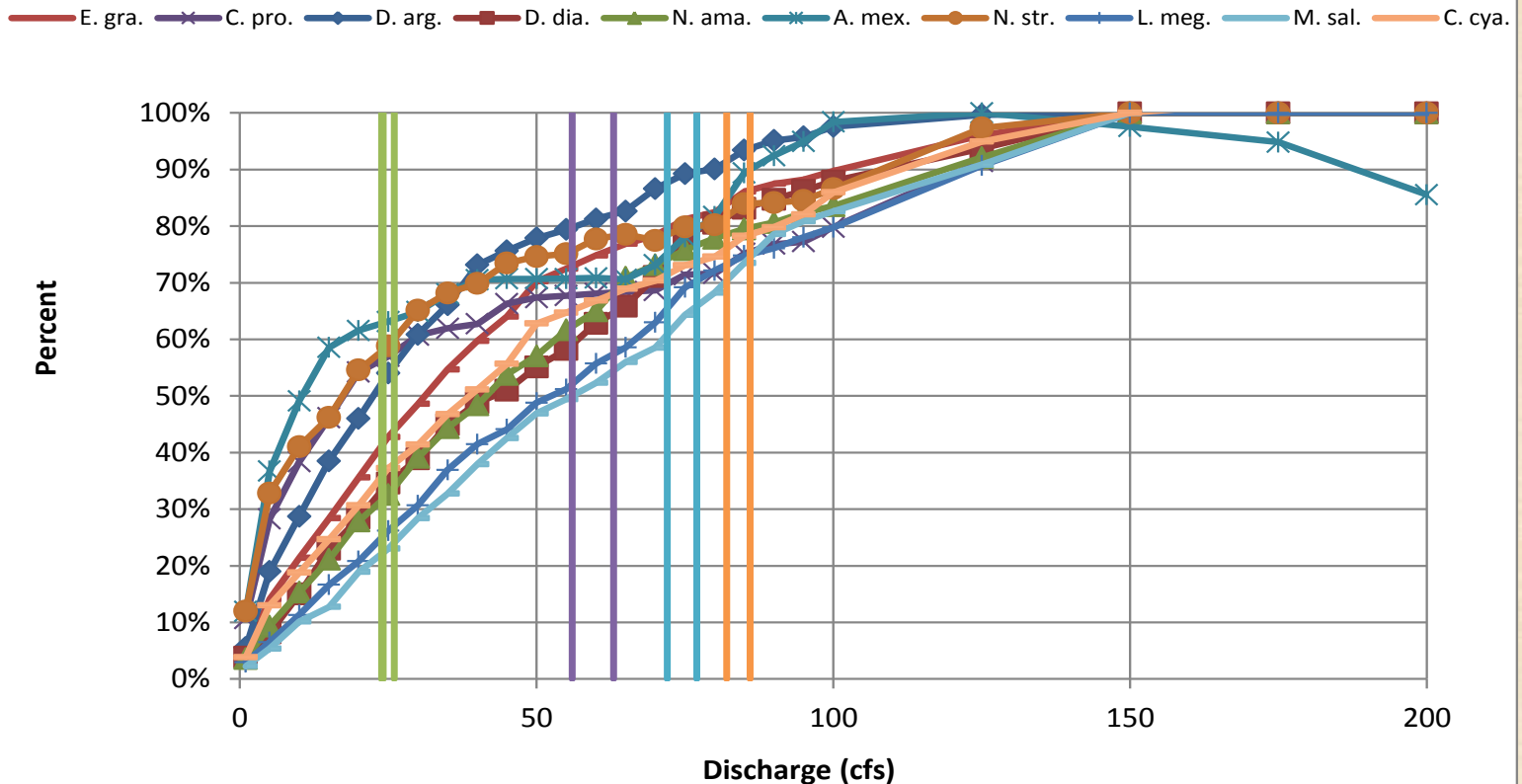
Water Quality

- No water quality impairments
- Somewhat increasing total dissolved solids
- Does not appear to be flow related



Devils River near Juno

Percent of Maximum WUA versus Simulated Discharge
Devils at TPWD SNA and TNC Preserve U/S of Dolan creek confluence
(xsec10_Riffle Total)



Devils

- 125 cfs needed to meet criteria for all species
- 1 in riffle

Modeled Flow (FT ³ /S)	C. pro.	D. arg.	D. dia.	N. ama.	N. str.	A. mex.	M. sal.	L. meg.	E. gra.	C. cya.
1	11%	6%	4%	4%	12%	12%	2%	3%	5%	4%
5	28%	19%	8%	9%	33%	37%	5%	7%	14%	13%
10	38%	29%	15%	15%	41%	49%	10%	11%	21%	19%
15	46%	39%	23%	21%	46%	59%	13%	17%	28%	25%
20	54%	46%	28%	28%	55%	62%	19%	21%	36%	31%
25	57%	54%	35%	33%	59%	63%	23%	26%	43%	37%
30	61%	61%	39%	39%	65%	65%	28%	31%	49%	41%
35	62%	66%	45%	44%	68%	68%	33%	37%	55%	47%
40	63%	73%	49%	48%	70%	71%	38%	41%	60%	51%
45	66%	76%	51%	54%	73%	71%	43%	44%	64%	56%
50	67%	78%	55%	57%	75%	71%	47%	49%	70%	63%
55	68%	79%	58%	62%	75%	71%	49%	51%	72%	65%
60	68%	81%	63%	65%	78%	71%	52%	56%	75%	67%
65	68%	83%	66%	71%	79%	71%	56%	59%	77%	69%
70	69%	87%	71%	73%	77%	73%	59%	63%	78%	70%
75	71%	89%	78%	76%	80%	78%	64%	69%	81%	73%
80	72%	90%	80%	78%	80%	82%	68%	72%	82%	75%
85	75%	93%	83%	79%	84%	89%	73%	75%	86%	78%
90	77%	95%	85%	81%	84%	92%	79%	76%	87%	80%
95	77%	96%	86%	82%	85%	95%	81%	78%	88%	82%
100	80%	98%	88%	84%	87%	98%	83%	80%	90%	86%
125	91%	100%	94%	92%	97%	100%	91%	91%	96%	95%
150	100%	100%	100%	100%	100%	98%	100%	100%	100%	100%
175	100%	100%	100%	100%	100%	95%	100%	100%	100%	100%
200	100%	100%	100%	100%	100%	86%	100%	100%	100%	100%
250	100%	100%	100%	100%	100%	86%	100%	100%	100%	100%
300	100%	100%	100%	100%	100%	87%	100%	100%	100%	100%
350	100%	98%	100%	100%	100%	86%	100%	100%	100%	100%
400	100%	92%	100%	100%	100%	85%	100%	100%	97%	100%
500	100%	79%	100%	100%	100%	69%	100%	100%	87%	100%

Devils River near Juno

- HEFR
- Plus, Biology overlay

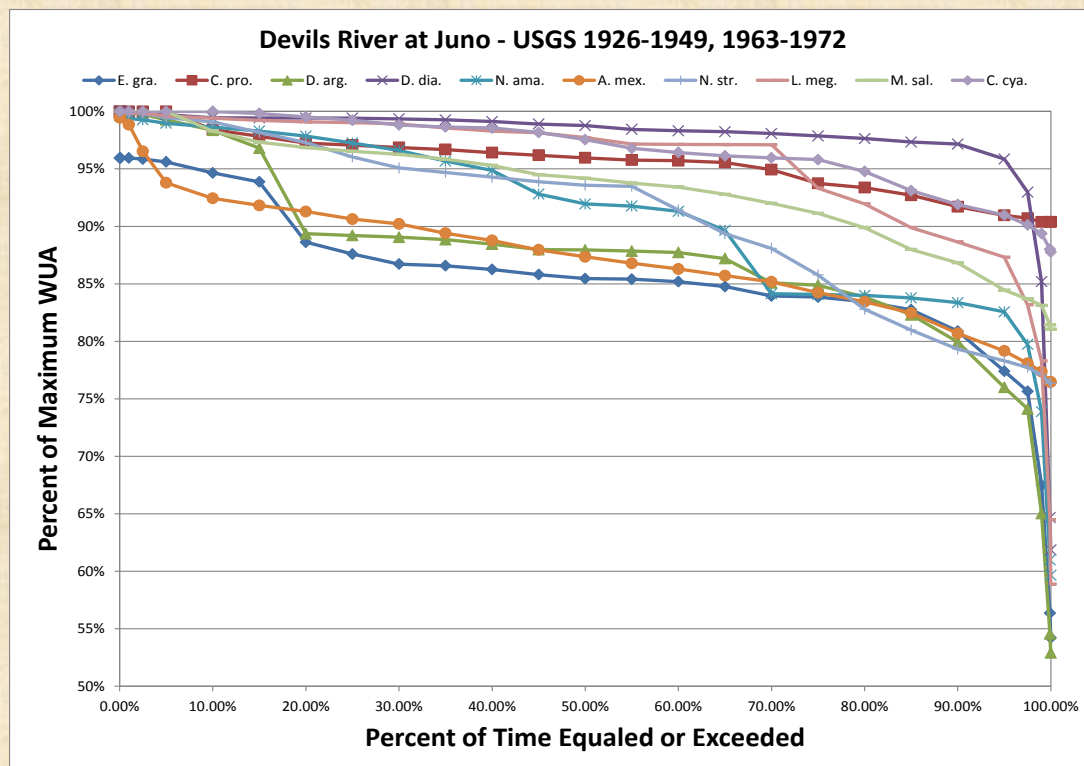
Overbank Flows	Qp: 39,200 cfs with Average Frequency 1 per 5 years Regressed Volume is 122,179 to 173,243 (147,711) Regressed Duration is 3 to 81 (17)											
High Flow Pulses	Qp: 15,900 cfs with Average Frequency 1 per 2 years Regressed Volume is 46,916 to 97,203 (72,060) Regressed Duration is 3 to 74 (15)											
	Qp: 3,570 cfs with Average Frequency 1 per year Regressed Volume is #N/A to 46,985 (21,870) Regressed Duration is 3 to 63 (13)											
	Qp: 2,340 cfs with Average Frequency 1 per 2 seasons Regressed Volume is 1,008 to 21,937 (11,472) Regressed Duration is 2 to 28 (8) Qp: 387 cfs with Average Frequency 1 per season Regressed Volume is #N/A to 16,813 (6,313) Regressed Duration is 2 to 30 (8)						Qp: 10,500 cfs with Average Frequency 1 per 2 seasons Regressed Volume is 21,134 to 87,932 (54,533) Regressed Duration is 4 to 114 (21) Qp: 990 cfs with Average Frequency 1 per season Regressed Volume is #N/A to 46,531 (13,068) Regressed Duration is 3 to 62 (13)					
Base Flows (cfs)	82 (54.2%)				84 (39.4%)				86 (49.4%)			
	74 (67.1%)				72 (61.9%)				77 (62.7%)			
	56 (81.6%)				59 (76.0%)				63 (76.9%)			
Subsistence Flows (cfs)	26 (97.1%)				24 (95.8%)				26 (95.3%)			
<div>NovDecJanFebMarAprMayJunJulAugSepOct</div> <div>Cold DryHot DryMonsoon</div>												
Flow Levels	High (75th %ile)											
	Medium (50th %ile)											
	Low (25th %ile)											
	Subsistence											

Notes:
 1. Period of Record used: 1/1/1926 to 12/31/1958.
 2. Subsistence and base flows calculated using non-zero flows only.

Overbank Flows	Qp: 39,200 ft ³ /s with Average Frequency 1 per 5 years Volume is 147,711 Duration is 17											
High Flow Pulses	Qp: 15,900 ft ³ /s with Average Frequency 1 per 2 years Volume is 72,060 Duration is 15											
	Qp: 3,570 ft ³ /s with Average Frequency 1 per year Volume is 21,870 Duration is 13											
	Qp: 2 ft ³ /s with Average Frequency 1 per 2 seasons Volume is 2,666 Duration is 15				Qp: 2,340 ft ³ /s with Average Frequency 1 per 2 seasons Volume is 11,472 Duration is 8				Qp: 10,500 ft ³ /s with Average Frequency 1 per 2 seasons Volume is 54,533 Duration is 21			
					Qp: 387 ft ³ /s with Average Frequency 1 per season Volume is 6,313 Duration is 8				Qp: 990 ft ³ /s with Average Frequency 1 per season Volume is 13,068 Duration is 13			
Base Flows (ft ³ /s)	125 82				125				125 86			
	125 74				125				125 77			
Subsistence Flows (ft ³ /s)	56 (81.6%)				59 (76.0%)				63 (76.9%)			
	26 (97.1%)				24 (95.8%)				26 (95.3%)			
Flow Levels	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
	Winter				Spring				Monsoon			
Flow Levels	High (75th %ile)				Notes:							
	Medium (50th %ile)				1. Period of record: 1/1/1926 to 2/28/1949 and 3/1/1963 to 12/31/1972							
	Low (25th %ile)				2. Subsistence and base flows calculated using non-zero flows only.							

Devils River near Juno

- Habitat time series analysis
- Can serve as an aid in evaluating standards
- E.g., no more than 10% decrease in frequency of meeting 90% threshold for imperiled species



Devils River at Pafford's Crossing

Overbank Flows	Qp: 34,110 ft³/s with Average Frequency 1 per 5 years Volume is 148,364 Duration is 22												
High Flow Pulses	Qp: 10,100 ft³/s with Average Frequency 1 per 2 years Volume 59,961 Duration is 16												
	Qp: 3,673 ft³/s with Average Frequency 1 per year Volume is 34,752 Duration is 13												
					Qp: 1,462 ft³/s with Average Frequency 1 per 2 seasons Volume is 21,327 Duration is 9				Qp: 6,816 ft³/s with Average Frequency 1 per 2 seasons Volume is 46,548 Duration is 14				
					Qp: 558 ft³/s with Average Frequency 1 per season Volume is 17,374 Duration is 7				Qp: 1,872 ft³/s with Average Frequency 1 per season Volume is 27,781 Duration is 9				
					Qp: 318 ft³/s with Average Frequency 1 per season Volume is 27,781 Duration is 9								
Base Flows (ft³/s)	243 (56.5%)				253 (41.5%)				238 (49.7%)				
	200 (69.0%)				207 (59.3%)				206 (62.9%)				
	175 (81.3%)				160 (74.5%)				166 (76.5%)				
Subsistence Flows (ft³/s)	84 (96.3%)				91 (94.1%)				87 (94.7%)				
	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	
	Winter				Spring				Monsoon				
	Flow Levels		High (75th %ile)			Notes:							
Medium (50th %ile)			1. Period of record: 1/1/1960 to 12/31/2009										
Low (25th %ile)			2. Subsistence and base flows calculated using non-zero flows only.										

Devils River – Adaptive Management

- Geomorphological overlay to ensure adequate HFP's to maintain channel processes
- Better understand groundwater relatedness and potential effects of groundwater development on ability to maintain SEE through permit conditions
- Refine habitat analysis to strengthen base flows
- Better understand flow biology
- Evaluate flow gage performance, relation of USGS period to current IBWC period

